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By ALEXANDER DUANE, M.D.
New York.

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SYMPTOMS.

Divergence-paralysis is a condition characterized by the following signs:

1. Sudden development of an *homonymous diplopia* with a marked convergent squint and with or without *vertigo, false projection,* and an *apparent movement* of objects looked at. The patient notices that the diplopia is particularly marked and confusing for distance (on the street, in church or the theater, etc.), but is absent in reading or sewing. If the diplopia is slight it can usually be obviated by tipping the head forward so as to direct the eyes slightly up. These subjective symptoms are often but little marked; and, in general, they are less pronounced than they are in a true muscular paralysis. e. g., in a paralysis of the externi, which superficially this condition resembles.

2. On examination we find that the amount of the diplopia and of the convergent squint, measured in degrees, is great for distance and *decreases with almost mathematical regularity as the object looked at is brought toward the patient,* until at a certain definite distance (usually a few inches) from him, there is binocular single vision. At the point where this begins there is still a slight tendency to undue convergence of the eyes (esophoria), but, as the object is brought nearer yet, the esophoria changes first into orthophoria (indicating the point where the eyes are in equilibrium) and then almost immediately into exophoria. This exophoria increases down to the point where the eyes can no longer

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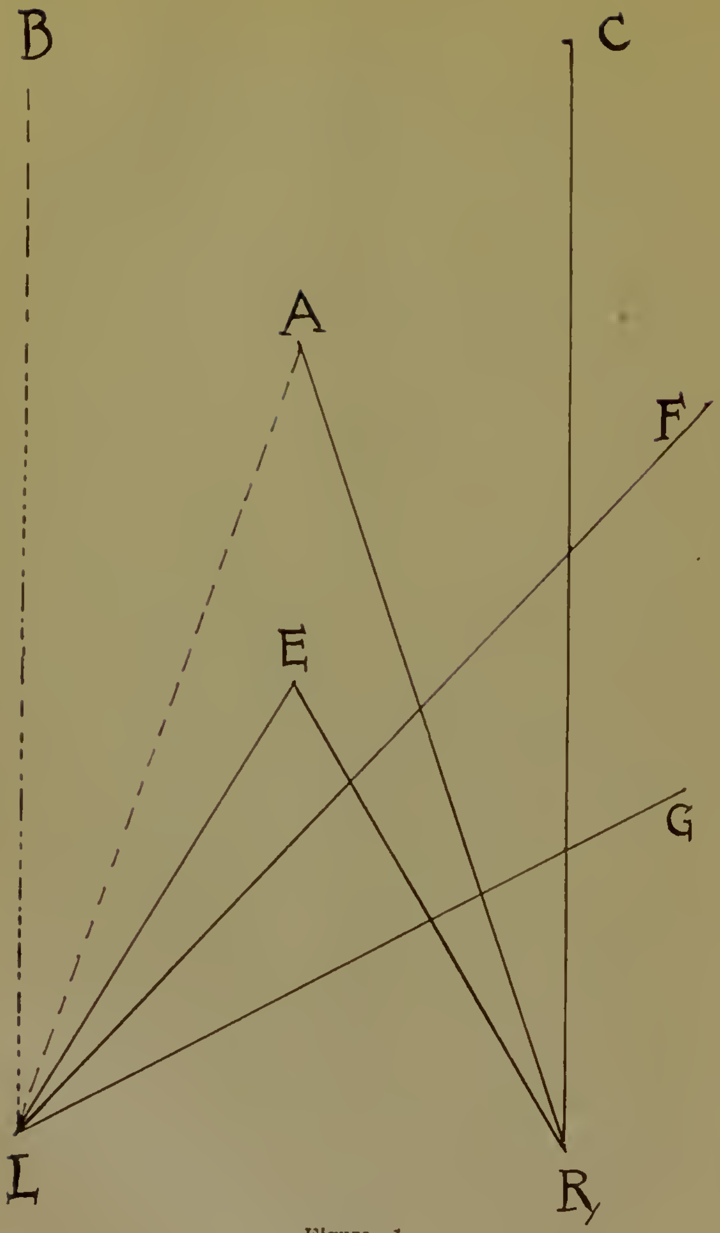

Figure. 1.

converge upon the object, i. e., down to the convergence near-point. This, instead of being abnormally close to the eyes, as we might suppose, is often rather remote (over 2 inches from the root of the nose). This is true, at least, of the uncomplicated cases. When a convergence-excess is present the convergence near-point may be unduly close.

3. In almost all cases, but particularly if there is much complicating convergence-excess, it will be observed that when the object of vision has been brought so close that it is seen single (*single vision by approximation*), the patient can then still hold the images together (a) when prisms, base in, of several degrees strength are placed before the eyes, or (b) when the object is slowly carried off again some considerable distance (*single vision by recession*).

4. The homonymous diplopia and the convergent squint do not increase—in fact they usually diminish somewhat—as the *eyes are carried to the right and to the left.** Diplopia and deviation diminish somewhat in looking up, increase in looking down.

5. The excursions of the eyes (even of the squinting one) are *normal in all directions.* Only, after the condition has lasted for some time, a slight restriction of outward movement can be observed, especially in the squinting eye.

6. The conditions found are *often strikingly stable.* The deviation and diplopia may increase at first until a certain maximum is reached, then usually remain the same for months or even years.

Closely allied to divergence paralysis, and, indeed, shading into it is the condition known as *divergence-paresis* or *divergence-insufficiency.* The distinction between a paralysis and an insufficiency may be made as follows:

DIVERGENCE-PARALYSIS.	DIVERGENCE-INSUFFICIENCY.
1. Development sudden, and subjective symptoms usually marked, at least at the onset.	1. Often no history of sudden development; spontaneous diplopia and other subjective symptoms often absent or little marked.
2. Amount of diplopia for distance marked (10 degrees to 50 degrees prism.	2. Less marked (0 degrees to 25 degrees prism).
3. Amount of diplopia for distance, measured by the prisms, base out, which just unite the double im-	3. Amount of diplopia for distance can be diminished by effort—the patient who at first just sees

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* In testing this the object should be carried along the arc of a circle so as to maintain a constant distance from the eyes.

ages, can not be diminished much by voluntary effort.	single with a certain prism, being able, by effort, to unite the images with a still weaker prism, base out, or even being able to overcome a prism of 1 degree or 2 degrees, base in.
4. At any given distance the amount of deviation, measured by the screen equals, or nearly equals the amount of insuperable diplopia measured in degrees.	4. At any given distance the amount of the insuperable diplopia is always less than the amount of the screen-deviation.
5. Range of single vision obtained when the object of vision is withdrawn from the eyes, i. e., the distance between the point where single vision is first secured when the test-object is brought up to the eyes, and the point at which single vision is lost again when the object is once more gradually carried off—is small.	5. Range of single vision on recession of object, large.

NATURE.

The condition present in this and similar cases is *distinguished from a bilateral paralysis of the externi* or from a *contracture of the interni* by two cardinal facts. First, there is no limitation of outward nor excess of inward movement in either eye. Second, the diplopia does not increase (in typical and especially in well marked cases it usually diminishes*) as the eyes are carried to the right or to the left.

From a *spasm of convergence*, the condition is differentiated, first, by its usually stable character; second, by the fact that the deviation diminishes progressively as the object of fixation is carried toward the eyes.

The only satisfactory explanation of the condition is that it is due to a *paralysis of divergence.* To understand the idea conveyed in this term, we must consider what occurs normally when we converge and diverge.

When we converge the eyes upon a near object we do so by means of an equal simultaneous contraction of the two interni.

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* Straub[10] was the first to call particular attention to this diminution, although Parinaud[5] first noted it. It was marked in Cases 1, 2 and 9 cited below. It is not, however, always present. It is probably due, as Berry[20] says, to the fact that in looking on one side we habitually converge our eyes less than when looking at an object straight ahead.

This contraction is effected by a special nervous mechanism, the true nature of which has recently been elucidated by Bernheimer[18] and Bechterew.[22]

Now, under normal conditions, when the eyes are thus converged, they may diverge again to look at a more distant object. When this occurs, the two interni relax and at the same time the two externi contract. This latter factor in the movement has been questioned (Graefe,[15] Berry[20]) but all the probabilities are in favor of it. Indeed, some clinical facts seem inexplicable unless we admit it. It appears, in fact, that when we diverge we have (a) an inhibition of the converging mechanism, and (b) a stimulation of a diverging mechanism, which appears to consist of the two abducens nuclei and certain cortical centers connected with them. (See Bechterew's investigations cited below.) Per contra, when we converge we have an inhibition of this mechanism and a stimulation of the mechanism for convergence. The eyes are thus balanced between two opposing forces, one always increasing as the other abates. In so doing they follow the law discovered by Sherrington[3] and Topolanski[13] that the mere act of stimulating the brain center for one movement inhibits the center for the opposing movement; and, per contra, the mere act of inhibiting one throws the other into action. Hence, if the mechanism for divergence is out of gear—in other words, if we have a *divergence-paralysis*—the eyes immediately assume a position of convergence, because the converging power is not only unopposed, but is also actually stimulated. Accordingly, the eyes are converged to a certain quite near point E (see Figure 1), which we may call the point of equilibrium. The function of divergence being abolished, the eyes can not be directed at any point beyond E by a mutual separation of the visual axes in the usual way. But they can still perform simultaneous parallel movements to the right or to the left, just as before. Hence, when the patient wishes to look at a point A more distant than E, he turns his right eye (R) to the right through the angle E R A, and turns the left eye (L) to the right, through an equal angle, E L F, so that the left eye squints in by an angle A L F = 2 E R A. It is evident that this angle of squint should increase in strict mathematical proportion as A recedes. In fact, in a deviation due solely to a divergence-paralysis, the squinting angle, B L G, when the eyes are directed at remote distance (i. e., when right eye is looking in direction R C), should theoretically be just equal to the angle L E R made by the visual axes when the eyes are in equilibrium (i. e., when the deviation is 0 degree).* In my Case 1 this correspondence was almost precisely exact. In other cases, in which the element of a convergence-excess is present (see infra) the squinting angle for distance is less than L E R.

The *diminution of the diplopia observed when the patient looks up* and its increase when he looks down are due to the fact that physiologically the eyes tend to diverge when directed up and to converge when directed down, so that a pathological homonymous diplopia, otherwise constant, is always less in the upper, and greater in the lower field.

HISTORICAL.

Cases of paralysis of divergence were first described by Parinaud in 1883,[3] and in 1889[5], then by Stölting and Bruns[6]; then by Uhthoff,[7] by Straub,[10] by Dor,[11] and by Sachs.[12] I described my first case in 1899.[16] At the meeting of the Heidelberg Ophthalmological Society in 1900, Bielschowsky[19] described three cases, and others were developed in the discussion. Three years before this I described[9] cases of this sort, in which there was not actual paralysis, but simple *insufficiency of the diverging action,* and pointed out how certain very troublesome cases of esophoria fall within this category. This fact has been still further elucidated by Wootton,[21] who has clearly demonstrated its practical importance in explaining the development and in determining the treatment of convergent squint.

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* If the angle of squint, i. e., the amount of deviation, for distance, expressed in degrees is denoted by S, then the amount of deviation S' at any nearer point B is denoted by the formula $S' = S - \frac{315}{D'}$, where D' is the distance of B in cm. from the base line connecting the centers of rotation of the two eyes. When $S' = 0$, i. e., when the eyes are in equilibrium, then $D' = D = \frac{315}{S}$; D, denoting the distance of the point of equilibrium from the intercentral base line. Thus, suppose the screen deviation and the diplopia for distance are just abolished by the prism of 20°, base out. Such a prism represents an actual deviation S of 11°. Then $D = \frac{315}{11} = 31$ cm., i. e., the point of no deviation or at which orthophoria would obtain is 31 cm. from the intercentral base line, or about 29 cm. from the root of the nose. At 100 cm. from the eyes the deviation $(S') = 11 - \frac{315}{100} = 7.5°$ actual deviation, corresponding to a prism, base out, of 15°. As a matter of fact, S and D are almost invariably less than they should be according to this computation: i. e., S is usually less than LER. The reason probably is that the very act of bringing the test object around the eyes begets a spasm of convergence which, as stated above, brings D unduly close. Moreover, it is to be considered that the attempt to look at distance in these cases represents really a turning of the eyes to one side. Now, in the divergence paralysis, the amount of the deviation tends to diminish as the eyes are turned to one side. Hence, especially if the degree of the paralysis is considerable S (— the amount of deviation for distance = really the angle made by the visual axes when the eyes are turned to the right or left through an angle of ERA), would be less than LER, or the angle made by the visual axes when the eyes are directed at a point in the median line.

The cases of divergence-paralysis, in fact, are not so very rare; and as pointed out in the article just mentioned,[16] v. Graefe, as far back as 1860[1] spoke of cases of this sort, but interpreted them in a way which we cannot now but regard as erroneous. Other instances doubtless occur in the literature of ophthalmology. See, for example, the case of Theobald's.[4]

CAUSE.

In six of the recorded cases (including my Case 1) an organic *brain lesion* appeared to cause the difficulty—there being a history of syphilis, tabes, multiple sclerosis, lead poisoning, or evidence of cerebral tumor. One other case appeared to be due to concussion of the brain[17] and still another (of long duration) to an antecedent pneumonia or pleurisy.[7] But, in the majority of cases the affection occurred *without obvious cause,* although from the suddenness of development and the permanence of the symptoms it seems not unreasonable to infer that it was due to a localized hemorrhage.

The condition in two of Uhthoff's cases was *preceded by a bilateral abducens paralysis,* and in one of Bielschowsky's appeared to go into a unilateral paresis of the abducens. Compare my Case 11, which may have started as an abducens paralysis; also Case 10, cited below.

Stölting's case started from what he calls an insufficiency of the externi, but what was actually, as his record shows, a very marked convergence-excess, which was increased, as is often the case, by the wearing of prisms. I have elsewhere pointed out[8] that this *superadding of a divergence-insufficiency upon a convergence-excess* is a frequent, indeed, a regular phenomenon. When this happens a deviation, which at first is marked for near-points only, becomes complicated by the addition of a similar deviation for distance.

Paralysis of divergence occurs at all ages (from 2 to 84) and about equally in the two sexes. It occurs more often in conjunction with hyperopia, but myopes are not exempt.

SITE OF LESION.

In the absence of autopsies we can only guess at the site of the lesion. A priori, it would seem probable that it would be found in close relation with the two abducens nuclei, whose actions are co-ordinated by some tract effecting the divergence function. This probability is perhaps strengthened by the fact already alluded to that a bilateral abducens paralysis may be converted into a divergence-paralysis, and, on the other hand, a divergence-paralysis may pass into a paresis of the abducens.

COURSE AND DURATION.

The duration of this affection is uncertain. The condition remained unchanged for five years in one of Uhthoff's cases, for at least four years in my Case 1, and probably longer still in Case 3; while in Dor's case (which was incomplete), the condition had decidedly improved, but was not yet completely cured in a year and a half from its onset. The subjective symptoms may improve or become less noticeable, although the condition itself remains quite stabile. (Cf. Case 6.)

The cases of divergence-insufficiency that I have seen seem to last indefinitely.

A divergence-paralysis or a divergence-insufficiency which has lasted some time is *often followed by a convergence-excess,* occurring either as a more or less transitory spasm or as a continuous, steady over-action of the convergence. This sequel, which is doubtles but another instance of the operation of Sherrington's law, produces a marked increase in the deviation for near. The deviation for distance may also be increased, but never to the same degree. The result is that the mathematical decrease in the amount of the deviation when the test-object was brought toward the eyes is no longer preserved, but the angular amount of the deviation and of the diplopia tends to become more nearly alike at all ranges. [8, 21] (Cf. Cases 2 and 4.)

The presence of such a marked convergence-excess may be inferred when:

1. The deviation for near is relatively much greater than it would be in a simple divergence-paralysis with the same amount of deviation for distance.*

2. The point of equilibrium is much closer to the eyes than it would be in a simple divergence-paralysis with the same amount of deviation for distance.

3. The point of equilibrium is much closer than the point of binocular single vision. (See Case 2, examination of June 1, 1901.) (See also Case 7.)

4. The distance of the point of equilibrium varies considerably from time to time without corresponding variations in the amount of deviation for distance. (See Case 4.)

Again, after a divergence-paralysis has lasted a certain time, the forced position of the squinting eye produces apparently *secondary muscular changes,* i. e., contracture of the internus, stretching and weakening of the externus. Then the range of inward movement in the affected eye is actually increased and the range of outward movement is actually diminished. (See my Case 2.) When this occurs the affection may be regarded as in a sense monocular; until then it is strictly a binocular condition[9], [24].

Divergence-paralysis may be complicated by a paralysis or spasm of one of the *vertical muscles* (see Cases 3, 4, 6), or an *association-paralysis* of up or down movement. Or, it may be *complicated with a paralysis of convergence* as in some of Parinaud's cases and in my Case 3. Moreover, the diminution in the amplitude of fusion that Graefe[23] noted as occurring in tabes and cerebral paralysis is often probably nothing but an example of the same combination. When such a combination occurs, the eyes assume a position of equilibrium beyond which they cannot diverge and within which they can not converge to any extent. Hence the range of single vision is limited to a space of a foot or so, or sometimes only an inch or two, within or beyond this equilibrium point.

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* I. e., S' is much greater and D is much less than they should be according to the formulæ, $S' = S - \frac{345}{D'}$ and $D_c = \frac{345}{5}$, given on p. 4 ante.

For all points beyond this range there is an increasing homonymous diplopia and for all points within it an increasing crossed diplopia. In the position of equilibrium the patient can not overcome prisms of more than a few degrees, base in and base out. The position of equilibrium itself may, according to circumstances, be either one of parallelism, of convergence, or of divergence. The similar *combination of a divergence-insufficiency with a convergence-insufficiency* is not very infrequent, particularly in neurasthenic cases.[9]

TREATMENT.

Correction of the *refraction* is of help mainly when a primary or secondary convergence-excess is present and aggravates the condition. In a pure divergence-paralysis glasses are of little use and may even aggravate the symptoms by enhancing the distinctness of the double images and so rendering it harder for the patient to ignore them.

In some instances, *prisms,* base out, have been used with advantage. Obviously, they are of service only when the deviation is slight. If there is much complicating convergence-excess, prisms may tend to make the deviation progressively worse.

In some cases* *tenotomy* of the interni has proved efficacious. It would seem particularly indicated when the element of a secondary convergence-excess is prominently present. Otherwise *advancement* of the externi would appear more rational. In any case an operation would be contraindicated unless we could feel sure that the process was stationary. In esophoria and convergent squint due to a divergence-insufficiency, advancement of the externi is indicated and gives satisfactory results[9], [21].

In the cases due to organic disease *internal treatment* is, of course, indicated.

APPENDIX.

Graefe[13] and Berry[20] believe that there is no such thing as an active divergence and that consequently there can be no such condition as a divergence-paralysis. Cases of the sort given in the present paper are in Berry's opinion really due to a spasm of convergence. This condition perhaps did hold for Berry's case, in which the conditions were more or less changeable, but certainly could not hold for my Case 1, and other similar cases in which the *conditions remained stable* for years.

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* Theobald,[4] Uhthoff,[7] Sachs,[12] Lederer.[19]

Quite impossible to explain on Berry's hypothesis are those cases cited above in which *both convergence and divergence were abolished,* for his explanation would involve the contradiction of supposing that in the same case there was at the same time a paralysis and an active spasm of convergence. Particularly instructive in this regard was my Case 3, because here the evidences of a paralysis of convergence were complete, and before the operation for advancement the eyes were practically parallel and remained so, no matter how near or how far the object of fixation was. In other words, they were constantly fixed on far distance. All that the operation did was to shift mechanically the point of equilibrium from far distance down to some 20 inches, and the convergence finally obtaining was due not to the spasm of convergence, but to the operation.

Furthermore, in cases of undoubted spasm of convergence, such as we see in children with beginning convergent squint, the amount of the deviation increases as the object of fixation is carried toward the eyes. In the cases now under consideration it *decreases.*

Again, the rather frequent condition that we call a *divergence-excess,* seems difficult to explain unless we concede the existence of an active diverging function. In these cases convergence is evidently normal, as shown by the following facts:

(a) The patient can readily overcome prisms, base out.
(b) The convergence near-point is normally close to the eyes.
(c) There is very little or no exophoria for near.

There is then no insufficiency of convergence, and the relations for near points are normal. Yet when the eyes are directed at distance there is a high degree of exophoria, or, it may be, a well-marked divergent squint. Moreover, the amount of exophoria increases as the object of fixation is carried away from the eyes—conditions the reverse of those which obtain in a convergence-insufficiency. It seems difficult to explain these cases except by supposing that there is an active diverging power which is here exerted to an excessive degree.

Lastly, Berry's ideas as to the non-existence of a substantive function of divergence are not in accord with the teachings of physiology. Apart from the positive results obtained by Bechterew.[22] which, if corroborated, would be conclusive against it, the idea that divergence represents merely a passive relaxation of convergence is opposed to all that we know of muscular action in general. Opposing movements elsewhere—flexion and extension, abduction and adduction—are invariably performed by the alternate contraction of opposing muscles, not by the alternate contraction and relaxation of a single muscle.

CASES.

In all of the subjoined cases it is understood that the diplopia and the deviation steadily diminished as the object looked at was carried toward the eyes until a point was reached at which the object appeared single (*single vision by approximation*). The (usually nearer) point at which the patient showed orthophoria is called the *point of equilibrium*. When the object, having been first brought up until single vision was secured, was carried off again, the patient usually was able to keep the double images united some distance out (*single vision by recession*). The situation of these various points is indicated by their distance from the base-line connecting the centers of rotation of the two eyes. In all cases the fundus was normal (except for the slight pallor of the discs in Case 1).

I have seen the following cases, including some of the more well-marked cases of apparently primary divergence-insufficiency:

CASE 1.[12]* *Strabismus Convergens of Six Years' Standing Due to Paralysis of Divergence. Associated Lateral Movements and Convergence Unaffected. Beginning Tabes.*—Mrs. J. H., aged 35, married. Seen at my office November 19, 1898.

History.—Six years ago attack of neuralgia, associated numbness and paresis of left arm, with sudden attacks of amblyopia. Then diplopia set in with a gradually increasing convergent squint. Ever since has suffered from various nervous troubles, especially neuralgic pains in the head (hemicrania) and spine (lightning pains).

In January, 1895, examined by Dr. Pischel, of San Francisco, who found an esophoria of 34° for distance, and of 20° for 40 cm. After operation, 14° for distance, 0° at 40 cm. Pupillary symptoms as now, but pupils slightly unequal. No other evidences of tabes at that time. Dr. Pischel did a tenotomy of the left internus, and later an advancement (capsular) of the left externus. This producing only an incomplete correction, he very properly proposed to do a similar operation upon the right eye, but this the patient refused.

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* Quoted from Arch. of Ophthal., vol. xxviii, 1899.

Head symptoms somewhat relieved by operation, but other symptoms very troublesome. Some of these attributable to uterine and ovarian disease, from which she suffers. Is using +0.50 sph. for distance and near.

Status Præsens. *Vision*: — 15/15 — each. R. accepts + 0.25 cyl. ax. vert. L + 0.50 sph. wi. + 0.50 cyl. ax. vert. Under homatropin, R. 15/50 wi. + 1.25 sph. 15/15: L. 15/70; wi. + 1.75 15/15. Accepts these glasses after effects of homatropin had worn off.

Field of Vision.—Perfectly normal for even the minutest test-objects and all colors.

Exterior of Eye.—Normal, except for old macula corneæ L. eye.

Pupils.—Of medium width, and equal. No reaction to light; slight but distinct reaction to convergence.

Fundus.—Normal, except for a well-marked sector of temporal pallor in both discs.

Muscles.—At fifteen feet, esophoria of 25° and 26° by all tests (screen, parallax, Maddox rod, phorometer). L. hyperphoria, 2°. Strictly monocular vision for distance, R. eye alone being used for fixation. No spontaneous diplopia for distance under ordinary conditions, but gets homonymous diplopia with red glass, and also when deviation is partly corrected by a prism of 13° base out.

Esophoria diminishing to 15° when the gaze is directed moderately far to either the right or the left. This diminution in lateral rotation apparent at all distances. Esophoria and the diplopia also diminishing progressively as the test-object is approximated to the eyes, until, at a distance from 20 to 25 cm. there is single vision and orthophoria. Within this limit there is exophoria. Convergence near-point 2 inches, or somewhat more from root of nose (i. e., slightly subnormal convergence).

Field of fixation, field of binocular single vision (at near), and excursion movements of eyes unrestricted in all directions. The outward movement, or abduction, greater than the inward movement (adduction) in each eye, and excursions of L. eye less than R. in both directions (abduction, R. 65°, L. 50°; adduction, R. 45°, L. 40°).

Extra-ocular Signs.—Romberg symptom. Absence of knee-jerk. No ataxia.

Subsequent examinations (the last one made January 26, 1899) confirmed the above findings in all respects.

CASE 2.* *Paralysis of Divergence, Consecutive Divergence-excess and Slight Contracture of the Internus.*—Mrs. S., aged 27, came on March 1, 1901, to the Ophthalmic and Aural Institute, service of Dr. Lynch. For two weeks, diplopia, vertigo, apparent movement of objects looked at. Symptoms especially marked when she is walking on the street. At near points has but little trouble and at the reading distance none at all. Two weeks before the symptoms appeared, fell down stairs, but apparently had no ill effects whatever from her fall beyond a few bruises on her body. No history of specific or other disease; no headaches.

Status Præsens.—Moderate degree of mixed astigmatism; V. 20/50. No change in fundi. Pupils equal, of moderate size, and react normally to light and convergence. Knee jerks normal. No anæsthesia of face. No paralysis of body muscles.

Convergent squint and homonymous diplopia *in all parts of the field of fixation*, but at all ranges *most marked when the eyes are directed straight* to the front, and diminishing considerably (to half the amount) when she looks either to the right or the left. Single vision by approximation at 17 cm.

Deviation by screen as follows:

	Prismatic Deviation.	True Angular Deviation.
At 5 m.	38°	23°
At 60 cm.	23°	13°
At 30 cm.	20°	11°
At 17 cm.	4°	2°
At 10 cm.	0°	0°

No restriction in outward movement of either eye; the outer margin of the cornea being readily carried to or beyond the outer canthus.

During the first eighteen days that the patient was under observation, deviation and diplopia increased until the latter became 50° (prism = 35° deviation of arc) at 20 feet and persisting down to about 4 inches from the eyes. Although she can fix with either eye at will, she usually does so with the right, so that the left is habitually in a position of marked inward squint. Owing to this forced position of the left eye, the diplopia now increases somewhat when she looks moderately to the left[*], but it *decreases once more when she looks still further to the left,* and the outward excursion of the left eye is still normal.

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* Presented at the meeting of the Section on Ophthalmology of the New York Academy of Medicine, March 18, 1901, by Dr. Lynch and myself.

The subjective symptoms, particularly the vertigo, have increased in severity, and there are now vertigo and an apparent movement of objects not only in binocular vision, but also *when the left eye alone is used for seeing.*[†]

	Prismatic Deviation.	Real Deviation.
At 5 m.	35°-40°	21°-25°
At 60 cm.	23°-36°	13°-21°
At 30 cm.		10°-16°

Binocular single vision at 16-17 cm. representing a convergence of 22°. Point of equilibrium at 8 cm. (representing deviation of 40° for distance); i. e., there is now, as before, a marked convergence-excess superadded to the divergence paresis. At 1 m. homonymous diplopia diminishing markedly to the right and the left; i. e., deviation has diminished considerably in amount, although its character is precisely the same. There is slight limitation of movement of left eye outward, due doubtless to the continuous forced positions of that eye inward (slight secondary contracture of internus). The case was followed for six months, during which period symptoms showed no essential change. Various fugitive pains in head. Moderate contraction of visual field in each eye, especially below, noted at two examinations. Never any indication of organic nerve lesion.

CASE 3. *Convergence and Divergence-Paralysis, Paralysis of Superior Rectus.*—Honora P., aged 22. At age of 13, without assignable cause, sudden development of vertical and lateral diplopia. Oculist found then a right hyperphoria of 9°. Various operations were done to relieve this. One of these producing a marked overcorrection, a tenotomy of the left superior rectus was done. When I first saw her (April 3, 1902) had a marked paresis of both superior recti, that of the right being probably altogether and that of the left partly due to the preceding tenotomies; also a (probably post-operative) insufficiency of the left inferior rectus. At 15 feet exophoria, and crossed diplopia of 2°. When this is corrected, can not overcome a prism of 1° either base in or base out. At 32 cm., exophoria 20° (screen) and at 35-40 cm. crossed diplopia overcome by prism of 13°. At this distance can also see single with a prism, base in, of 14°, and sometimes with one of 12°, but with prism of 11° gets insuperable crossed, and with 15° insuperable homonymous diplopia; i. e., at all ranges convergence and divergence of not over 1° prism (= ½° actual deflection). Lateral rotations of both eyes normal. Reaction of pupils to light well-marked; to convergence nil. Accommodation normal. Afterward by practice succeeded in running up the diverging power at distance to 5° (i. e., net diverging power of 3° when exophoria was corrected) and the converging power to 8° (= net convergence of 10-8°). Could also reduce the crossed diplopia at near-points to nearly 0°. At times can turn left eye in well in convergence, and then there is a well-marked convergence-contraction of the pupils. All her attempts at overcoming prisms, base out, marked by evidences of great effort (contraction of frontalis and orbicularis, etc.), and, moreover, she can never hold the images together for more than a moment. Continued practice carried her no further.

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[*] Cf. Uhthoff's first case.[7]

[†] Sachs[12] has called attention to this feature of these cases, in which, although the affection is bilateral, monocular projection may be interfered with.

In September, 1902, an advancement of left internus produced, as the primary result which also had remained the permanent result during two and a half years of observation, the following:

For distance homonymous diplopia of 8° to 10°. Diplopia continues down to about 40 cm.* where she gets single vision, which is almost immediately succeeded by crossed diplopia. Range of single vision not more than 5 or 6 cm. (sometimes not over 3 cm.) and, at the midpoint of this range, divergence and convergence after considerable training about 4° each (but sometimes can not do 1° either way). As before, occasional momentary convergence by spasmodic effort. Excursion of right eye over 60° out, and over 65° in; of left eye 45° out and 55° in.

The advancement thus simply shifted her point of equilibrium from far distance down to a point about 1½ feet from the eyes.

CASE 4. *Paresis of Divergence with Convergence-Excess.*—Mrs. J. W. C., aged 33. Seen March 12, 1901. Asthenopia; blurring of vision for near work. No diplopia noticed, except occasional vertical diplopia in reading music. Under homatropin showed: R. + 1.25 sph. + 0.25 cyl. 70° 15/15. L. + 2.50 sph. 15/30. Pupils of medium width and equal; all reactions normal. Left esotropia of 10-11° and homonymous diplopia of 10° for distance reducible sometimes by effort to 6° or 7°. Single vision by approximation at 30 to 45 cm.; by recession 1 m. or more. Point of equilibrium usually at 15 to 22 cm., but at times (evidently under the influence of a temporary convergence-spasm, which is probably due to accommodative effort) the equilibrium-point is brought as near as 11 cm., and then there is an increase in the amount of esophoria for distance and a still greater increase in the amount for near. Diplopia and convergent squint increasing somewhat when she looks down and diminishing when she looks up; diminishing moderately when she looks to the left, and remaining about the same or possibly increasing slightly when she looks to the right. With her glasses (partially correcting her refraction) convergent squint for distance is reduced to 7°, although she still usually has homonymous diplopia at all distances beyond 1 m. and her point of equilibrium is at 30 cm. Varying vertical diplopia (left hyperphoria) increasing (sometimes rather markedly) in looking down and to the right. No limitation in the movements of either eye.

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* This point of equilibrium receded later to 57 cm.

In January, 1903, findings the same in all respects, except that the tendency to vertical deviation had disappeared.

Here there was evidently in addition to the divergence-insufficiency a well-marked convergence-excess. This was the case even when the accommodative element was largely eliminated by a partial correction of the refraction. For, with a prism-deviation of only 7° or 8° for distance, representing an actual deviation of arc of only 4°, the point of equilibrium should have been nearly 1 m. from the eyes if the case had been one of divergence-insufficiency. As a matter of fact the equilibrium point under these conditions was at about 30 cm. from the eyes, and when the accommodation was called particularly into play (either by disuse of the glasses or by the initial effect of an instillation of homatropin, which often causes marked temporary accommodative effort) the equilibrium point was approximated to 22, 17, or even 11 cm., and the amount of esophoria for near-point was unduly increased.

Case 5. *Divergence-Paresis.*—Miss S. C. M., aged 84. For years has had diplopia for distance, and to relieve this has worn prisms, now using R. + 1.00 cyl. 25° ○ prism 4°, base out; L. — 1.00 sph. ○ prism 5°, base out.

With her glasses V. = 15/80 each (poor vision due to incomplete cataract). Without her glasses has for distance homonymous diplopia of 14°, which by effort she can reduce to 7°. About the same amount of deviation by screen and Maddox rod. Diplopia not increasing to either right or left; increasing somewhat in looking down, diminishing in looking up. Single vision by approximation at 30 cm. Little or no vertical diplopia in any part of the field of fixation.

Case 6. *Paresis of Divergence.*—Mrs. J. R. H., aged 62, seen January, 1905. Two years ago L. eye suddenly began to squint, and at the same time began to see double in church and on street. No vertigo. Got glasses containing prisms (thought to be 2½° each, base out) and more recently present glasses (+ 1.75 c. prism 1°, base out, each, for distance, and + 5.00, without prisms, for near). Diplopia has remained about the same in amount since onset of trouble. Sees better when she throws head forward so as to look up slightly. R. + 2.00 + 0.25 cyl. 90° 15/15. L. + 1.75 + 0.25 cyl. 180° 15/15. For distance, with her correction, shows

	Diplopia corrected by prism of		Real deviation of
5 m.	22°	=	12°
2 m.	20°	=	11°
1 m	14°	=	7°
0.5 m	8°	=	4°

Single vision by approximation at a little less than 1 m.; by recession out to about 1 m. with her near glasses. Point of equilibrium at about 20 cm. For distance R. convergent squint of 22° (prism = 12° actual deviation). Homonymous diplopia same or increasing very slightly in looking to right and left. Inconstant and changing vertical diplopia, indicating spasm or insufficiency of depressors. No restriction in outward movement of either eye. Pupils react to light.*

Case 7. *Divergence-Insufficiency.*—Alexander C. M. P., aged about 68. Seen April 11, 1900, and conditions essentially the same when seen in October, 1902. No diplopia nor other symptoms referable to the eyes, except an irritation, apparently the result of a mild conjunctivitis. R. —1.00 cyl. 170° 15/15 +; L.—0.25 cyl. 55° 15/15+. Homonymous diplopia of 10° for distance, and convergent squint of about this amount or less. Point of equilibrium 18-20 cm. Single vision by approximation at 1 m.; by recession out to 5 m., at which distance he gets alternate single vision and homonymous diplopia. At times by effort can even overcome a prism of 2°, base in, for distance, and if the test-object is at 30 cm. he can overcome a prism of 10° or 12°, base in.

Case 8. *Divergence-Insufficiency.*—Arthur A. D. B., aged 26.

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* This case has been repeatedly examined since and has always shown precisely the same relations (last examination, June 24, 1905), although the diplopia is much less annoying than formerly.

Seen April, 1902. Asthenopia dolens and blurring of sight in reading. Supraorbital and ocular pain. Using for four years R. + 0.50 + 0.25 cyl. 180°; L. + 0.75 + 0.50 cyl. 180°. Under homatropin shows R. + 1.00 15/15 —; L. + 1.50 15/30 —. Without and also with glasses (R. + 0.75; L. + 1.25) shows for distance esophoria 1°-1.5° (parallax and phorometer), 2° (Maddox); prism divergence, 1°; with red glass homonymous diplopia which persists down to about 3 feet from eyes. At 25 cm. exophoria 1° to 5°. Convergence near-point normal. At 35 cm. prism-divergence of 9° and afterward of 10°.

The following cases occurred in the practice of Dr. Colman W. Cutler, and I am indebted to him for the privilege of examining them:

Case 9. *Divergence-Paresis.*—G. F. R., male, aged 24. No history of syphilis, rheumatism or exposure to cold. General health excellent. Habits good (smokes moderately). Worries a good deal over his business. Eight days before Dr. Cutler saw him, suddenly developed diplopia after going to the theater. No headache, nausea or vertigo. Diplopia for distance only, but reading causes fatigue. Under atropin shows R. and L. + 0.25 + 0.25 cyl. 180°, which he is using.

For distance (Dr. Cutler's examination of March 17 and 19 and mine of March 21, 1903), alternating convergent squint of 20° to 25° (prism), homonymous diplopia of same amount, but can fuse images with a much weaker prism (remains of diverging power). Single vision by approximation at 29 cm. At all ranges diplopia diminishing as eyes are carried to either right or left. On March 28, 1903, deviation and diplopia for distance still 29°, but now single vision by approximation at 60 cm. and single vision by recession at 68 cm. At 1 m. homonymous diplopia diminishing to single vision as eyes are carried up, or laterally, or far down. Ignores diplopia most of the time. Heard later that after going to the country he got completely well so far as his subjective symptoms were concerned.

Case 10. *Divergence-Paresis with Consecutive Convergence-Excess and (also probably Consecutive) Insufficiency of the R. Externus.*—F. B. M., male, aged 31. Seen Dec. 10, 1903. No previous illness of any kind. Eyes always good. No diplopia until six days ago, when as he was sitting in the theater, he suddenly began to see double. Diplopia passed off, but recurred the next day, and has been increasing ever since. No headaches nor vertigo. For distance R. convergent squint of 20° (prism) by screen test; homonymous diplopia of 25° by Maddox rod, but only 16° with the red glass. At 33 cm. screen-deviation = 10° (prism) = 5° actual deviation; at 15 cm. screen-deviation = 0° actual deviation. At 1 m. and 5 m. homonymous diplopia diminishing greatly in looking to the left; diminishing slightly or remaining the same in looking to the right. Slight vertical diplopia (R. hyperphoria). Rotation of each eye outward at least 45°, but R. not quite as good as L., and in looking to the right both eyes make nystagmoid twitchings. In passing from the position of eyes-left to eyes-front, L. eye evidently moves faster than R.; this faster movement of the outer eye not noticed in passing from eyes-right to eyes-front. Projection normal for R. eye when directed either to right or left. and for L. eye when directed to left. Pupils equal and reactions normal. Knee-jerks abolished.

After taking large doses of potassium iodid (up to 60 grains t. i. d.) began to improve in about two weeks. When seen in March, 1904, has prism 4°, base out, each, for distance. These rest eyes, but does not use them much. No spontaneous diplopia for three weeks. Now shows at 5 m. deviation =9° (prism) =4.5° actual deviation: at 27 cm. deviation = 10° (prism); 14 cm. deviation = 0°. For distance homonymous diplopia changing to single vision. In eyes-right, deviation = 14° (prism). In eyes-left, deviation = 5° (prism). Movement of R. eye outward slightly limited.

At 75 cm. slight homonymous diplopia, noticed especially in right half of field, although it is less in amount in eyes-right than in eyes-front.

Here there was evidently a consecutive convergence-excess and also a (probably consecutive) insufficiency of the R. externus.

Since the above article was written the following additional case has been observed:

Case 11. *Divergence-Paresis Probably Consecutive to a Paralysis of the Abducens.*—C. Y. K., male, aged 47. Fifteen years ago severe attack of articular rheumatism; had some eye trouble then, which caused him to miscalculate distances and for which he used prisms, base out.

Just two months ago sudden attack of blurring of sight and diplopia. with some uncertainty of gait, but no marked diplopia. Is confident that at that time diplopia increased markedly when he looked to the right.

Took large and increasing doses of sodium iodid, and diplopia nearly or quite disappeared, even for far distance. It has, however, recurred for the last week or two. He has himself noticed that the diplopia is present mainly when he looks at distant objects, and is nearly or quite absent in near work.

Two days ago, without warning, sudden severe attack of vomiting and diarrhea, which led him to discontinue the iodid.

Status Præsens.—Exterior and interior of eyes normal. V. = 15/15 each. R. strabismus convergens; deviation by screen = 24° (prism); screen deviation same whether correcting prism is put before right or left eye (i. e., *primary exactly = secondary deviation*). Homonymous diplopia of 25° (prism) for distance, *diminishing as test-object is approximated* to the eyes, until at a distance of 12.5 cm. from the eyes both the diplopia and the screen deviation become 0. With test-object at 3 feet, homonymous diplopia of 15 inches, *diminishing* moderately as eyes are carried to right and markedly as eyes are carried to left. Rotations of each eye normal in all directions. In particular, there is not the slightest limitation of outward rotation in each eye.

Here, if we can judge from the history, there was at the outset a paresis of the right externus, but the picture that is now presented is that of a pure divergence-paresis. Whether the slight pathologic convergence that he had fifteen years ago was due to the same cause or not is, of course, uncertain.

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